

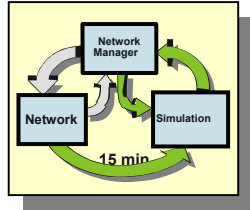


On-Line Simulation and Control



OSC Objectives

- Integrating network simulation into near-real-time network management, with value added:
 - Transaction level metrics computed for the real network.
 - Near real-time simulation for "what-if" studies
 - Continuous real-time validation of simulation
 - Testbed for multiple simulators.
 - Standards for simulation in network management.



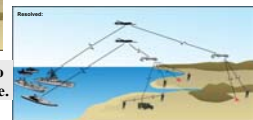
Potential Benefits

- Improved Operational Effectiveness of communication networks.
 - Improved ability to detect and respond to network problems.
 - Network manager knows user is unsatisfied before a complaint arrives
 - Network manager can service disconnected users who



Real-time redesign repositions two remaining UAVs to serve everyone.

A UAV has returned to base for refueling. A group has been cutoff from the net.



Uses and National Security Opportunities

Functions

- Planning
- Staged deployments
- Event/Attack Detection
- Replanning, (attack response)
- SLA Systems
- Training

Military/Government Projects

- National Guard
- Coast Guard
- JNMS (Joint Network Management System)
- JTRS (Joint Tactical Radio Systems)
- FCS (Future Combat System)
- Netcentric Sensor Modeling



Innovative Approach

- Define a "valid simulation" as one whose predictions of user level of quality of service are only limited by our ability to predict future network conditions.
- Instrument the simulation, not the real network. Collect only enough information from the real to build a valid simulation, and use the simulation to compute metrics of interest.
- Run Simulation continuously side by side with real network, with continuous feed back/validation against measured metrics.
- Utilize standardized set of interfaces to provide transparency to analysis and simplify transportability.

Interfaces and Standards

Communication Traffic Evolving Standards

SEAMLSS THREADS
<pre> # The additional lines (END INTERVAL, END RUN) relate the last report for this interval and # the last report for the run of the simulation, respectively. The values in parentheses # (i.e. i-h) allows one to keep their simulation clock in sync with the producer's clock. # # UID Start (s) End (s) Source Ip Dest Ip Protocol Bytes Sent # END INTERVAL (i-h) # END INTERVAL (i-h) # END INTERVAL (i-h) # END INTERVAL (i-h) </pre>

Network Topology Evolving Standards

SEAMLSS SDF
<pre> \$ File Name: osdemo.sdf \$ \$ Created on 3/2/01 \$ Using SDF_Ver2.1 \$ \$ PDEF File for entity type: 610_19931_1001 \$ \$ Created on 3/2/01 \$ Using SDF_Ver2.1 \$ \$ Using SDF_Ver2.1 \$ \$ Using SDF_Ver2.1 </pre>

Network Tuning (No Standard Yet)

Simulation

Terrain (No Standard Yet)

MIB Statistics Per HPOV

Number of values which occurred between the last report (start time) and this report (end time), both reported in seconds (s). The IP address in the host which caused the occurrence, and count is the number of times the value occurred since the last report.

#	Start (s)	End (s)	IP Address	Count
0.0	2.9	0.001	0	0
0.0	2.9	0.003	0	0
0.0	2.9	0.005	0	0
0.0	2.9	0.007	0	0
0.0	2.9	0.009	0	0
0.0	2.9	0.011	0	0
0.0	2.9	0.013	0	0
0.0	2.9	0.015	0	0
0.0	2.9	0.017	0	0
0.0	2.9	0.019	0	0
0.0	2.9	0.021	0	0
0.0	2.9	0.023	0	0
0.0	2.9	0.025	0	0
0.0	2.9	0.027	0	0

Operational Metrics based on SEAMLSS Thread Log

Simulation Name	Host	IP	Port	Protocol	Bytes	Packets	Errors	Discards	Queue	Wait	Time	Unit
17/NEW	21/xxxxxxx	0	88	0	1020	34	46651	-116	300	636	940	
17/END	21/xxxxxxx	0	88	0	1020	34	46651	-116	300	636	940	
19/NEW	5/xxxxxxx	0	73	0	1024	34	42880	-116	265	627	348	
19/END	5/xxxxxxx	0	73	0	1024	34	42880	-116	265	627	348	
19/NEW	21/xxxxxxx	0	88	0	2020	34	46651	-116	300	636	940	
19/END	21/xxxxxxx	0	88	0	2020	34	46651	-116	300	636	940	
19/01513/RCV	1/xxxxxxx	0	73	0	1024	34	41911	-116	255	627	348	
19/01513/END	1/xxxxxxx	0	73	0	1024	34	41911	-116	255	627	348	
19/00305/RCV	5/xxxxxxx	0	73	1	1024	34	42880	-116	265	627	348	
19/00305/END	5/xxxxxxx	0	73	1	1024	34	42880	-116	265	627	348	



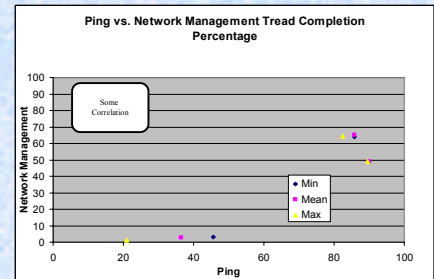
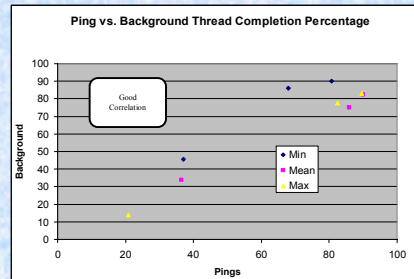
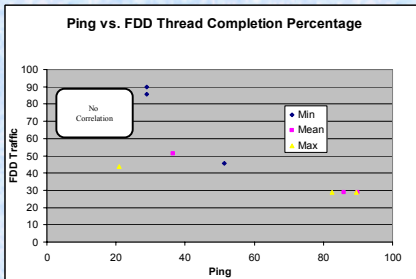
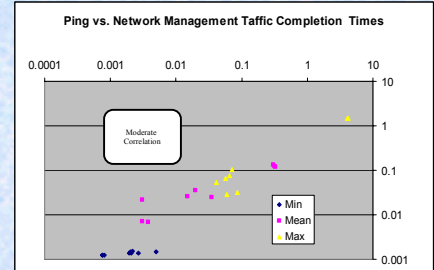
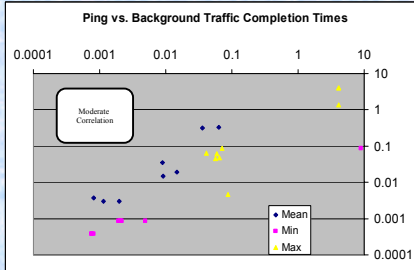
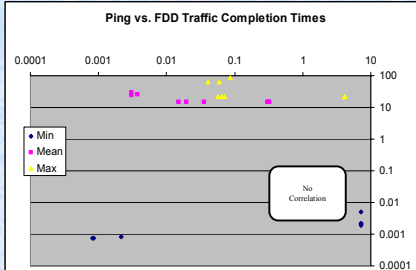
Correlation of Ping QoS with Operational Performance

Purpose:

1. Study the correlation of ping metrics to operational performance to determine the usability of pings to assess network performance.

Methodology

1. Create a matrix of scenarios with traffic at Low, Medium, and Heavy load levels and each with and without pings added to the traffic. Multiple levels of ping traffic were added. ~ sixteen cases per scenario.
2. Run simulation in SEAMLSS environment with QualNet for each case and analyze overall user level QoS.
3. Create analysis plot(s) to expose any correlation between the ping and the other traffic. Such correlation is required in order that ping measurements have value for monitoring user satisfaction.



Effect on QoS of Adding Pings and Network Management Traffic to Ambient Threaded Traffic in a Single Network

Purpose:

1. Determine the effect on the QoS of adding Ping and Network Management Threads to baseline traffic in single Network

Methodology

1. Create a series of four simulations that include 1. baseline traffic, 2. Baseline traffic plus pings, 3. Baseline traffic plus network management traffic, and 4. Baseline traffic plus ping and network management traffic threads. Calculate the QoS for the network in each simulation.
2. Create an analysis plot that will allow comparison of the QoS for the network under each traffic loading condition.

Scenario Description

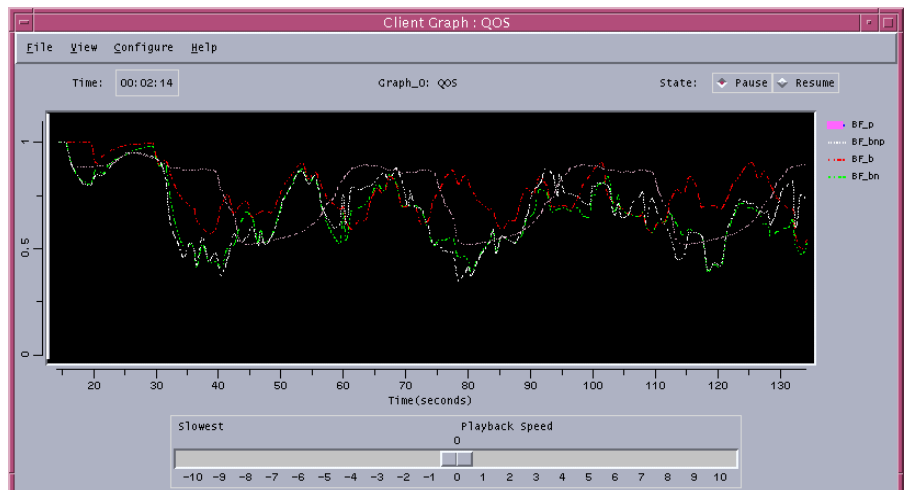
The scenario is a variant of a 64 node Ship to Objective Maneuver (STOM) scenario originally developed for the JTRS Program.

Various QualNet radio models are used, Dawn, AODV, and ACC Noise with Bellman Ford routing protocol. To keep simulation times short, freespace propagation is used. Radios are set to a transmit power level of less than one watt.

Baseline traffic for all simulations is the JTRS FDD traffic as used in the Naval Forces Simulations of various STOM scenarios. Traffic consisted of a mixture of data messages sized from 1000 Bytes to 100,000 Bytes in length.

Ping Traffic was 10 Bytes in length, every 35 seconds. Pings were sent from 5 nodes such that all nodes received one ping and were required to respond.

Network Management Traffic was 40 Bytes in length, every 40 seconds. Network management threads were sent from each node to one node. No response was required.



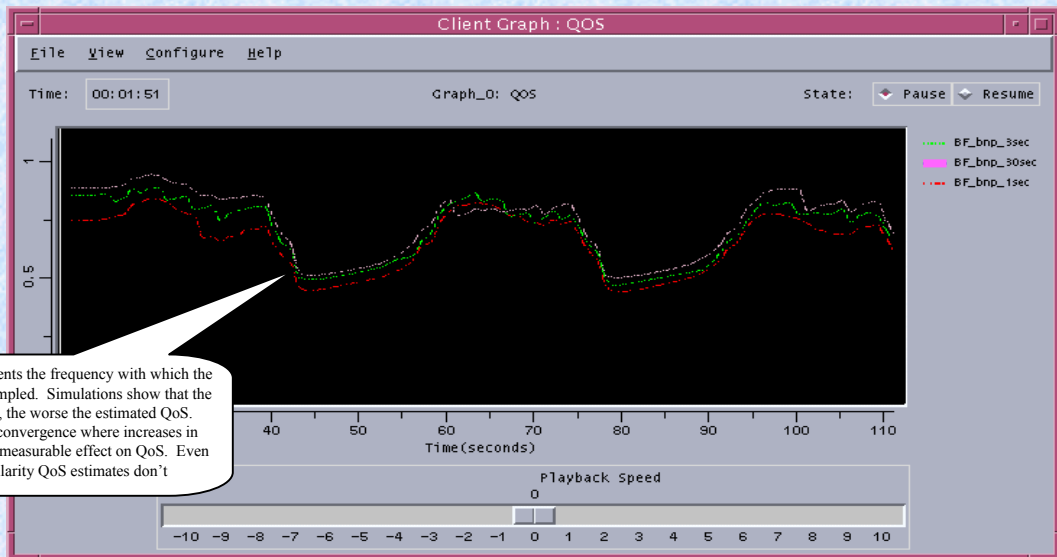


Data Collection Granularity Impact on Simulation Validity

Purpose: Determine the effect of network sampling rate on the measured QoS of the network.

Methodology

1. Create series of scenarios with various target network sampling rates and calculate the QoS for the network at each sampling rate.
2. Create analysis plot(s) that expose any correlation between the sampling rates and their associated network QoS.



Sensitivity of Simulation Run Time to Traffic Conditions

Purpose: Analyze the relationship between simulation run time and various traffic loading factors

Methodology

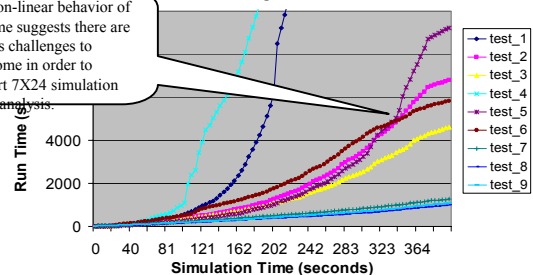
1. Conduct a series of SEAMLSS simulations to using various radio models and traffic load levels and record the simulation time and corresponding run time ("clock" time) and record the data.
2. Create analysis plot(s) to illustrate the relationship between simulation time and run time for the various models and load values.

Future

1. Explore various factors that might influence the simulation time - run time relationship to identify cause/effect relationships.

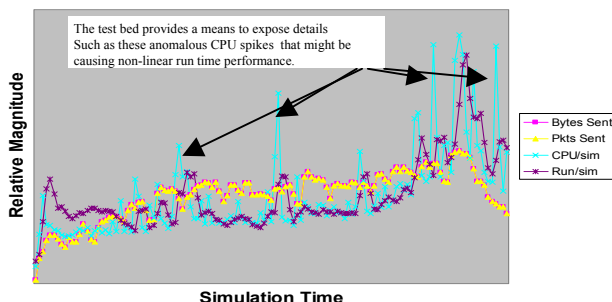
Run Time vs. Simulation Time for Various Traffic & Routing Protocols

The non-linear behavior of run time suggests there are serious challenges to overcome in order to support 7X24 simulation based analysis.

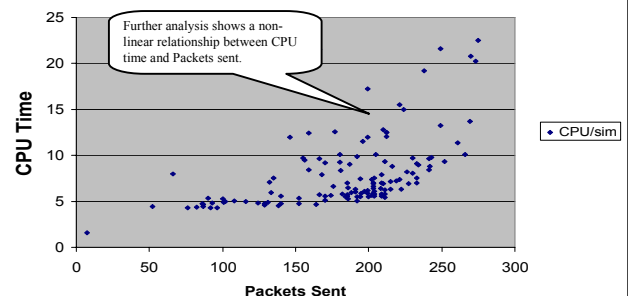


Execution Time vs. Traffic Load

The test bed provides a means to expose details such as these anomalous CPU spikes that might be causing non-linear run time performance.



Correlation of CPU Time vs. Packets Sent





Demonstration

Study Application of Network Simulation to Real-time Network Management.

Purpose

1. Provide multiple NM&S projects means to demonstrate their relevance in military operations.
2. Test ease of use for network simulation in field.
3. Provide means to explore use with next generation wireless networks that do not physically exist.
4. Provide reproducibility for controlled experiments.
5. Remove extraneous variables that prevent analysis of results.

Methodology

1. Studies are for single network and are in accord with military doctrine for network size. Inter-network simulation is architected to be a distributed simulation with each network manager simulating a network.
2. Scenarios for JTRS type military operations are supplied by SAIC in standard SDF format. Current focus is Navy STOM (Ship to Objective Maneuver), selected from several scenarios each for Army and for Navy operations at sizes ranging from 60 to 600 nodes.
3. A GUI shows how to set up a live real-time simulation for a scenario.
4. One simulation using QualNet, is used as a "stimulator" to mimic a real instrumented network. It outputs appropriate instrumentation data on timed intervals in evolving format.
5. Multiple simulations, also using QualNet, import the collected data as it is generated and run simulations of different protocols for comparison.
6. Data is output in standard HPOV format.
7. Real-time displays begin to show the analysis possibilities

